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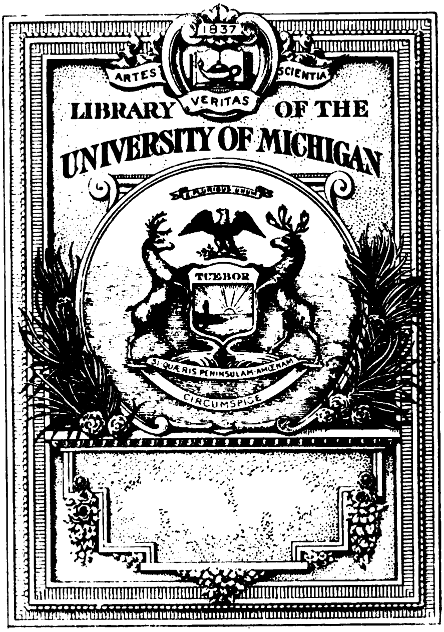

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A WONDER BOOK OF RUBBER

DR. BENJAMIN FRANKLIN GOODRICH
Founder of The B. F. Goodrich Co.

By

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The B. F. Goodrich Rubber Company

GOODRICH EMPLOYEES READING COURSE
VOLUME I

A WONDER BOOK *of* RUBBERS

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Written in
THE SALES TRAINING DEPARTMENT
of
THE B. F. GOODRICH RUBBER COMPANY
Akron, Ohio

Book No.............

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THE B. F. GOODRICH RUBBER COMPANY

WE are not offering this book as a scientific discussion of rubber. Neither are we offering it as a complete review of the industry. These things have been treated often.

This story is only what its name implies—A Wonder Book—written in response to the demands of a healthy curiosity which has sprung up in the minds of our friends concerning the rubber industry—one of the newest of the great industries of the world.

Reclass. 11-22-27 A.V.M.

To the Goodrich Organization:

IN accordance with the well known practice of this Corporation to place at the disposal of its employees every means whereby a comprehensive knowledge of our business may be obtained, the publication of a series of eleven books has been authorized, of which this volume is a part.

Dealing as they do with every angle of the rubber business, past and present, from the gathering of the basic crude material to the marketing of the various finished products, these books have been written with the idea solely of treating the subjects from the sales standpoint.

It is the hope that every employee of The B. F. Goodrich Rubber Company will aim to acquire a knowledge of the Corporation's products as well as business practice, and a careful study of these books will increase your knowledge, broaden your scope of vision and increase your usefulness to the company and yourself.

These books represent largely the cumulative result of my establishment of the Sales Training Department about six years ago. I commend them to your careful attention.

Very truly yours,

W. O. RUTHERFORD,

Director of Sales.

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CHAPTER ONE

The Story

WAY back yonder, many years ago, in the "Once Upon a Time," in the mythical period following the creation of the "Aladdin Lands" of the tropical jungles of America, an Indian, perhaps at play, perhaps on the hunt, perhaps at war, perhaps in search of food—discovered rubber. He found it oozing from the bark of a tree and having thoroughly convinced himself that it was by no chance eatable, lost all interest except that of curiosity heightened as the strange substance congealed into a sticky mass in his hands.

Even as you and I would have done, our nameless native probably experimented with this mass by rolling it into a ball. Perhaps, tired of his new plaything, he threw it to the ground or at the nearest tree. You can imagine his surprised look when the ball bounced back at him. He picked it up and examined it with a new interest. Reaching camp he tossed it to one of his friends—and the great American game of baseball found a beginning.

The Indians named this new-found plaything "Batos" (ball). The substance from which it was made they called "Cahuchu" (some tribes called it "Caucho") which translated means "weeping tree."

His brothers, curious and envious, started a search for materials that they too might be possessors of a wondrous "Batos." One of them dropped some of the fluid on his foot or his arm, or on his leg, and discovered that it coagulated into a sheet, and thus the Indians learned to make moccasins which would protect them from the wet and from the rocks; bottles in which they could carry water. Hats were formed, and wondrous ornaments fashioned, the like of which the Indian had never before imagined.

One, more curious than his brothers, discovered that the smoke of the palm nut added snap to the finished article and that "Cahuchu" lasted longer when smoked. He forgot that it had ever been a curiosity and accepted it as he accepted all of the other things which the Great Father showered upon his children of the tropics. Thus "Cahuchu" came into use in the every day life of the Indian.

Such is the mythical tale of the discovery of rubber. The story undoubtedly extends over hundreds, even thousands of years. It is a story made more interesting because it took the white man three hundred years to improve the Indians' methods of manufacture. The Indian method of coagulation has never been improved on.

Columbus was the first white man to know anything about rubber. When he set sail a second time for the "East Indies," his men were induced to go with him by the lust for gold. Gold was supplied for the expedition in the hope of getting more gold. Columbus himself had little more than a commercial interest in this trip. Unfortunately, he had never heard of Indian "Black Gold" or he might have loaded his ship with it and returned home a wealthy man instead of a pauper to be thrown into chains.

Columbus reported to the Queen that he found the Indians playing a game with a wonderful ball made from the gum of a tree. Spanish and Portuguese missionaries, following Columbus, also made reports on this new substance utilized by the Indians in their games, dress and ornament. In 1525 these reports were compiled into a book and given to Spain as wonder tales of the new world.

These reports did nothing, however, but arouse curiosity which soon died out, except in the mind of the curio hunter, who never tired of collecting the strange articles of ornament and clothing that were shipped back to Europe and sold at a profit by men who were bold enough to go after them. It took two hundred years to arouse a desire for definite information concerning rubber's growth and uses. Two French explorers, in 1731 made the first effort under the guidance of the Paris Academy of Science.

These men explained in their reports just where rubber came from and how the natives gathered it. They described and sent back samples of the articles of clothing used by the natives, and from them Europe heard for the first time of the Hevea tree. Later, explorers presented the King of Portugal with a complete suit of rubber clothing.

In 1770, Priestley, the discoverer of Oxygen, while experimenting with a rubber ball sent him by a friend, discovered that this ball would erase lead-pencil marks. So far as we know, this is the first practical use ever given rubber by civilized man. This incident also has the historical distinction of having given rubber its name. Priestley was so pleased with his new found plaything that he cut it into chunks and gave them to his friends, calling them "rubbers."

It is interesting to note in this connection that the term "rubber" is found only in the English language.

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Every other language, lacking a Priestley, has adopted some derivative of the words "cahuchu" or "caucho." (French—"Caoutchouc"; German—"Kautshuk").

Despite the fact that the Indians from the earliest times used this material for clothing, shoes, water bags, and ornaments, the first rubber trade from America consisted merely in the collection of curios. Following Priestley's time, the practicability of the adoption of rubber into the commercial life of the civilized world began to appeal to many men with a scientific turn of mind. Once the study was begun, developments occurred in quick succession.

In 1791, Samuel Peal of London spread melted rubber on cloth and announced that he had discovered a practical method of building waterproof clothing. Although he manufactured and marketed a number of coats and capes, his experiment was short-lived.

In 1820, another Englishman, Nadier, discovered a method of cutting rubber into threads and weaving these threads into cloth and in the same year Thomas Hancock opened what is generally recognized as the first rubber factory in London. While we are unable to verify this statement, we are inclined to believe that Mr. Hancock's factory was built to manufacture clothing after the process invented by Nadier. At any rate, this experiment, too, was short-lived, because three years later (1823) Thomas Hancock discovered that rubber was soluble in turpentine and in the same year, Macintosh discovered that it was soluble in coal tar and naptha. Macintosh immediately opened a clothing factory utilizing his discovery and his name has ever since been synonymous with waterproof clothing.

In 1836, two men, Hancock an Englishman, and

Chaffe, an American, discovered that rubber cut into strips and subjected to kneading under moderate heat, lost its elasticity and could be molded into any desired shape. This discovery marks the greatest advance in the development of the industry until 1839, when Charles Goodyear, an American, discovered the process of vulcanization.

Charles Goodyear is the man to whom the rubber industry owes its very life. Until his discovery that rubber mixed with sulphur and subjected to heat, vulcanized into a dependable material, unaffected by ordinary changes of temperature and climatic conditions, there was never the slightest possibility that rubber articles could be made which would prove practical in actual service.

Before Goodyear's discovery articles made of rubber were of little commercial value because of the fact that rubber in its natural state will become soft and tacky in hot weather, while in cold weather it gets stiff and brittle. Vulcanization overcame these natural traits of rubber, and the way was open for its general use. The business of manufacturing rubber goods immediately started on its onward march to present day proportions.

Histories of the early industry usually end with the story of Goodyear, because his discovery marks a new epoch and the modern history savors more of commercial development than of abstract experiments of the pioneer.

Akron, Ohio, became the rubber center of the world through accident. Dr. Benjamin Franklin Goodrich, Hospital steward of the 9th New York Cavalry, dissatisfied with his prospects at the close of the civil war, went into the oil business. He was not successful in this venture and drifted to New York, finally entering the real estate business. After a series of transactions, he found himself saddled with a small rubber factory in Hastings-on-the-Hudson. Dr. Goodrich attempted to make good on this investment by running the factory but was handicapped through lack of funds.

One day, Dr. Goodrich met a friend from the little village of Akron, Ohio. In their talk about business prospects, Dr. Goodrich was induced to come to Akron to talk over with some of the leading business men, the proposition of moving his factory west. Col. George T. Perkins called this meeting and after investigation, nineteen men loaned Dr. Goodrich $1,000 each. With this money and $5,000 which was loaned to him by Mr. Morris, his real estate partner, he came to Akron in 1869 and erected the first building. Today twelve such plants could be put in one of the mill rooms of the present factory.

Happily, Dr. Goodrich lived to see the day when his plant was the greatest of its kind in the world. His happiness could not be complete, however, for though he was able to build his commercial dreams into realities, he lost his battle for health and after many years of suffering from the ravages of tuberculosis, died alone in his room at Manitou Springs, Colorado, August 3, 1888, still comparatively a young man.

The rubber industry in Akron naturally centered around The B. F. Goodrich Company. Rubber was a new thing and the business men of Akron, watching the growth of The B. F. Goodrich Company, were able to see its possibilities and the history of practically every early Akron rubber company is the same. A group of business men would form a selling company and contract

sensational

with Dr. Goodrich to make special brands of goods for them. Men would be put out on the road and the business developed to the point where it could support a factory of its own. When the factories were built, naturally they were located in Akron, because Akron was the home of the men interested, and because The B. F. Goodrich Company had trained in Akron a great share of the skilled rubber workers of the country.

This is the story of more than a dozen of the better known rubber companies in the country today.

CHAPTER TWO

Rubber—What?

YOU can probably touch with your hand, twenty-five articles made wholly or in part of rubber.

Rubber articles have become so common that we very rarely think of the part this commodity plays in our daily lives. Unless we deliberately count them, we never think of rubber in connection with soles, heels, overshoes, supporters, buttons, belt buckles, bandages, stays, raincoats, erasers, fountain pens, pipe stems, tobacco pouches, pocket books, hair pins, spectacles, and chewing gum. These are all articles with which we are intimately acquainted, but until they have been grouped for us, we never realize how dependent we are upon rubber for our personal comfort.

At our desk we can reach out and touch the telephone with its many rubber parts, the top on the ink well, the pen holder, the push button on our call bell and the cord leading from it, the rubber stamp with which we date our letters, the erasers and the rubber bands. If we are in a field of sport, what would it mean to us to take the rubber from our golf ball, our tennis ball, our baseball, our basket-ball, our football, or push ball, our billiard table, and the hundred and one other articles connected with sport lines. An automobile has nearly fifty parts of rubber.

There is no industry that is not benefited in some way by rubber. There is no man whose personal comfort and whose business is not affected by some article of rubber which is used constantly; yet there are few who realize this fact. The scope of the rubber industry is so great that we have come to look upon it as a matter of course. To illustrate: The B. F. Goodrich Company of Akron, Ohio, alone manufactures nearly thirty thousand different articles ranging all the way from the great Hydraulic Hose in the gold mines and the mammoth Conveyor belt of the refinery to the minutest rubber thread in milady's hair net and the accessories which have made possible much of the work of surgery.

Rubber is an elastic, resilient substance derived from the latex or milky juice of certain tropical trees, vines, and shrubs. It is not, as is commonly supposed, derived from the sap after the fashion of maple syrup or sugar, but on the other hand is taken from the latex of the bark. Plants with rubber producing latex are found nearly the world over and range from the great Hevea and Castilloa trees of South America, the mammoth Landolphia vine of Africa and the scraggy Guayule bush of Mexico, to the lettuce and asparagus of our garden, and the milkweed which is the bugbear of every "kid" who has lived on a farm and had to pull them out of the oats field.

Scientists disagree as to Nature's purpose of the latex. It is thought by some to serve as a reserve supply in the times of drought; others claim that it is a protection to the trees. Very few insects seriously attack a rubber plant unless forced by a scarcity of other food. Still other scientists are of the opinion that this latex is a healing agent that protects wounds until healed. Perhaps it is best for us to accept all three theories and add to them the thought that mayhap in the great scheme of the Great Builder there was some thought of the comfort of His children.

The latex of the rubber plant is carried through the bark in a series of small veins, best likened to the lymphatic system of the human body. This latex is about as thick as thin cream and is just a trifle pink.

The analysis of the latex of the Hevea tree, the best known and most widely used of the rubber plants, is approximately:

Rubber	37%
Albumin	3%
Resin	5%
Water	52%
Traces of oil, sugar and other matter	3%

The chemical formula for rubber is $\mathrm{C10H16}$. This same symbol is used for turpentine and isoprene; the difference between the three being in the arrangement of the molecules.

In its natural state, rubber is insoluble except in certain volatile oils. This characteristic gives it the virtue of being waterproof. On the other hand, it warns us that oil is the natural enemy of rubber.

Perhaps some day we will be able to define rubber as other articles of commerce are defined, but today we are only able to say that this peculiar substance, derived from a tree, coagulated, will, under certain conditions, act thus and so. This is more interesting when we remember that in nearly four hundred years the world's greatest scientists have failed to surpass the old Indian method of coagulation by the use of palm-nut smoke.

CHAPTER THREE

Where Does Rubber Come From?

WHERE does rubber come from,—and what will happen when the supply is exhausted? These two questions are asked us every day.

Almost any part of the world lying between the thirtieth parallels will produce rubber in commercially paying quantities. This makes a belt of five hundred miles, lying two hundred and fifty miles on either side of the equator. A small fraction of this area could, under intensive cultivation, supply the world's rubber needs with very little effort.

There are about three hundred and fifty known varieties of rubber, about one hundred of which have been adapted to commercial use. These varieties, while having some characteristics in common, are just as distinct from each other as are the different varieties of apples, or peaches, or pears.

A rubber plant in order to thrive, needs a warm moist climate. In the best producing sections the temperature runs from 80 to 120 degrees Fahrenheit, while the rainfall averages about 81 inches.

The original source of supply was the Amazon river district of South America and rubber plants in their wild state are here found in dense thickets. While a great many varieties of plants produce rubber in this section, the industry is based mainly on the production of two trees, the Hevea Braziliensis and the Castilloa. The Hevea tree is directly centered on the tributaries of the Amazon;

the Castilloa tree thrives best in southern Central America and northern South America, extending into the tributaries of the Amazon. These two trees not only have always produced the greater share of wild rubber, but have become the base of the plantation industry as well.

The early history of the rubber industry naturally centers around Brazil. Realizing her power, Brazil used every precaution to protect the monopoly which nature had given her. In 1876, however, H. A. Wickham, an Englishman, smuggled a cargo of the Hevea seeds out of the country and these formed the base of the present plantation industry. Some day, you will want to read Mr. Wickham's story of the thrilling experience and the hardships he encountered for the sake of the few seeds he was able to take with him.

These seeds were planted in Her Majesty's Own Garden, at Kew and then transplanted at Ceylon and other British possessions in the East Indies. This was the foundation of the plantation industry which in a few short years has grown from nothing to the biggest factor in the rubber trade, far overshadowing its parent country, Brazil.

Today, rubber used in the manufacture of ordinary articles of commerce, comes from South America, Central America, Asia, Ceylon, The East Indies and Africa. African rubber is used more generally in Europe than in the United States, mainly because Europe has succeeded, through constant experimenting, in removing the impurities in African rubber. Every year, however, European manufacturers are coming more and more to adopt the American plan of using Para rubber as a base. Para rubber is so-called because Amazon rubbers were originally cleared through the city of Para.

The present yearly production of all varieties is about one hundred and thirty thousand tons. Ninety-five thousand of this comes from plantations, thirty thousand from Brazil, and five thousand from the rest of the world. One-half of the world's total production of raw rubber is used in the United States. One-fourth of the world's production finds its way to Akron, Ohio, and the world's largest rubber plant, that of The B. F. Goodrich Company uses one-sixth of the world's production every year.

Perhaps some day a scientist will discover or invent a synthetic (artificial), rubber which will be practical. At present, however, there is very little indication that such a discovery is near at hand. As the price of rubber goes down, the problem becomes greater, because the aim in producing artificial rubber is to make it cheap enough to compete with natural rubber. Several men have succeeded in making artificial rubber which will stand most of the tests, but the price has always been prohibitive.

With natural rubber as low in price as it is at the present, and with apparent prospects of becoming cheaper, there is very little need for a substitute. Could it be produced at a reasonable price, however, artificial rubber would protect us from future repetition of a condition brought about by the European war. From the beginning of the war, Germany and her allies found themselves suffering a rubber famine. The need for rubber was so acute that the bulk of the cargo that went back to Germany on the first merchant submarine, the Deutschland, was made up of rubber. Germany passed laws making it an offence punishable by a fine, to throw away old rubber articles, to make sure that every scrap might be used over and over again.

This condition also affected the United States. When war was declared, England immediately placed an embargo on rubber and for a few weeks it was impossible for American manufacturers to obtain any of this raw material. England, however, found that she needed American made rubber goods and eventually lifted the embargo on all American concerns who would agree not to sell crude rubber or any product made from rubber to an enemy of England.

CHAPTER FOUR

Plantation Rubber

EFFORTS have been made to stimulate the rubber plantation industry in practically every country that lies within the tropics. Ceylon and the East Indies are famed for their pioneer work in putting the rubber plantation on a paying basis and paving the way for an inexhaustible supply of raw material. Mexico, perhaps not so justly, is also famed for its rubber plantations.

Central America, South America and Africa are all experimenting feverishly and bid fair to have some success. A half serious attempt to commercialize the milk weed, which abounds in the Mississippi Valley, has been made in the last few years.

Our application of the words "perhaps not so justly" to Mexico, and her efforts in the plantation industry, is meant to call your attention to the number of fake schemes, and "Wallingford" corporations that have characterized the Mexican rubber industry in the last few years. Someone who pretends to have counted them, says if all the Mexican rubber companies that have sold stock in the United States are truthful in their statements, the plantations overlap several times and then extend a considerable distance into the sea. This may or may not be true, but it is at least safe to say that there have been many questionable statements made concerning proposed Mexican Plantations.

The best known and most successful rubber plantations are found in the island of Ceylon. Most of these are using the Hevea and Castilloa trees, although a number of different varieties are being experimented with. The Ficus tree (Ficus Elastica), is used quite extensively to protect divisions of plantations from infectious diseases and insects.

It may interest you to know that the Ficus tree is the common household rubber plant. It has comparatively little commercial value except as a preventer of disease. Diseases which attack one tree will not always attack trees of a different variety, and plantations are laid out with this thought in mind—very much after the idea of plowing furrows around a house to protect it from prairie fires. The plantation is laid out in sections, each section being divided by a row or perhaps two or three rows of a variety of tree which is not subject to the ordinary diseases of the producing tree. These borders effectively prevent the spread of the disease over the whole plantation.

The Hevea tree, which is the backbone of the rubber industry, grows to a great size, often sixty feet in height and six feet in circumference. It is very hardy and will grow under almost any conditions which are tropical in their nature. It thrives best, however, in damp, low-lying lands with a minimum temperature of 80 degrees Fahrenheit. To show its hardiness it grows in Ceylon, three thousand feet above sea level. It can be safely tapped, some say, in the third year, but the majority recommend waiting until the fifth or sixth year. At this time its girth has reached 18 or 20 inches.

Hevea seeds are about the size of a hickory nut with a smooth surface much like a castor bean. They are first planted and reared in a nursery. When the young plants have reached about twelve inches in height, the shade of the nursery is gradually lessened in order to harden the plant to the conditions of open growth. They are transplanted to a permanent field when they are about the height and size of a nursery fruit tree.

Ordinarily trees are planted fifty to two hundred to the acre, running in squares from 15 x 15 to 30 x 30, depending upon the peculiar ideas of the planter in charge.

The average annual yield of a plantation Hevea after the fourth year is about one-half pound per tree, increasing annually by one-quarter pound. As yet we are unable to determine just how long this increase continues, because in plantation work all records show that the trees under observation have increased annually. Some experts say also that the quality of the rubber increases with the age of the trees.

The cultivation of the rubber tree, its pruning and care, the fertilization and drainage of the soil, the question of "under crops" and like subjects, have been under discussion, but as yet no definite rules are laid down. Each plantation owner follows his own ideas, based on his own experience and the recommendations of the various governmental departments, which are making a study of the horticultural angles of the industry.

The Hevea tree, cultivated, can be tapped every day without seriously impairing its health. Most trees, however, are given periods of rest. These periods of rest vary in their frequency and length, according to the ideas of the planter. Some allow one day of rest per week; some one day per month; some one week per year; and still others one month per year. This is a distinct advantage over the same tree in its wild state, because tropical conditions are such in its natural home that it can be tapped each year only one or two short periods during the dry season.

CHAPTER FIVE

Harvesting

MOST of you know how maple sap or "Sugar water" is gathered. Rubber is gathered very much the same way, except that in gathering sugar water a hole is drilled into the tree through the bark, while in gathering rubber a gash, just deep enough to go through the outer shell of the bark, is cut with a small axe about the size of a lath hatchet. Sugar water is the sap of the tree, rubber is the latex of the bark.

Rubber trees in their wild state, grow in swampy forests many times hundreds of miles from civilization; forests so thick, so overgrown with shrubs and vines that it is impossible to go through without cutting a path as you go. In South America, most of the rubber lands are controlled by the government and it is necessary to secure a grant before gatherers can be taken into the forests. This grant is taken out by a man whom the rubber gatherers call an "aviadore." In this country we would probably call him the contractor.

The aviadore hires the rubber gatherers or "seringueiroes" and having supplied them with food and clothing sufficient for several months, sends them into the forest, hundreds of miles up the Amazon or its tributaries. When the men reach the plot of land on which the government has given them permission to work, they build a little town made up usually of a manager's house, a store and a series of huts in which the natives are to live. This little settlement is known as a "seringal."

When the seringal has been finished, the men are ready to go to work. Each native is allotted a space in the forest containing as many rubber trees as he can attend to every two or three days. He starts out from his hut the first day and with his axe, cuts a path through the forest in a loop. Two or three such paths are cut by each workman. Each loop represents a day's work and usually touches from fifty to seventy-five trees. The native calls one of these loops an "estrada." Everything is now ready for the gathering of rubber.

Each morning the native goes over his estrada carrying with him his tapping axe and a number of little receptacles about the size of a paper drinking cup. These are ordinarily made of tin although the more primitive tappers sometimes used gourds and cocoanut shells. He taps each tree several times and under each incision he sticks one of his little cups. All this tapping is before breakfast, so having completed the round of his estrada, he goes back to his meal of beans, dried beef and farina,—a sort of tapioca flour.

Immediately after breakfast, he retraces his steps, empties the cups into buckets and returns to camp, ready for his real day's work. The latex which he has collected is about as thick as thin cream and must be coagulated at once to keep it from spoiling.

The coagulation, or congealing, removes the water from the latex and leaves a solid mass. This can be done in many ways. If left to stand, the sun will do it; but the sun also rots the rubber. The South American favors one method of coagulation; he has used this one method for hundreds of years, perhaps, before civilization ever heard of rubber.

The Indian builds a sort of furnace which resembles a funnel turned up-side down under which he builds a fire of palm nuts and sticks. Soon he has a thick black oily smoke coming in a steam through the small opening at the top. He then takes a paddle and dips it into the bucket of latex and moves it back and forth in the smoke until it is covered with a thin layer of coagulated rubber. The paddle is dipped into the bucket again and again; going through the same smoking process until the ball on the end has grown so big that it can be no longer handled. The paddle is then removed and a long stick pushed clear through the ball. The Indian then rests the ends of this stick on other forked sticks which have been driven into the ground on each side of the furnace. Turning the ball or biscuit round and round over the fire, he slowly pours on the latex from his bucket until his day's collection has been cured.

He does not start a new biscuit each day. In fact, it takes several days to build an ordinary biscuit and when one is cut open, it is very easy to see where one day's work stopped and another began.

The farther up the river he is working, the larger he is liable to make his biscuits. A big biscuit can be carried down the river with less chance of being lost than a small one. The term "biscuit" is ordinarily used to designate the smaller balls of rubber gathered in those sections near the mouth of the Amazon where transportation facilities are fairly good. These biscuits usually run from eight to twelve pounds in weight. The larger biscuits are known as "hams" and often weigh as much as one hundred and fifty pounds, sometimes even more, and represent ten or twelve days tapping by one native.

Not all South American rubbers are gathered and coagulated in the way just described. This is the best method and fortunately the most common. The value of raw rubber to the manufacturer depends very materially on the method by which it has been gathered and prepared. Rubber which is kept free from dirt and coagulated in such a manner as to keep it from rotting is worth a great deal more to the manufacturer than rubber that is carelessly gathered and coagulated.

In contrast with the careful methods of the South American Indian, we have the African methods which are careless in the extreme. The tapping methods of African gatherers are necessarily very similar to those of South America, but the careless methods used in the coagulation are responsible for the reputation for low quality which African rubbers have received. In fact, African rubbers, if properly treated, are just as valuable as those from South America.

The lazy native of Africa very often lets the rubber flow down the side of the tree to a hollowed-out place in the ground, rather than take the trouble to attach cups. He lets the rubber lay here until it has coagulated. In some sections a little more care is exercised and the native lines the hole in the ground with leaves. In other African districts, the native apparently doesn't care to wait for natural coagulation to take place, and to hurry matters, he spreads the latex as it comes from the tree, over his body. Through no fault of his own the heat and perspiration of his body effect a comparatively good coagulation. At the end of the day, he tears this suit, which he has built for himself, from his body and rolls the thin strips into balls.

This savage who takes no thought of the future has but one idea. His one desire is to get as much rubber as he can in the shortest time. Not only has nature helped to give him this attitude but his acquaintance with the white man has given his instinct a foundation. We have all heard of the cruelties practiced in the rubber holdings of King Leopold of Belgium; the maiming and killing of natives who failed to bring in enough rubber to satisfy their task-masters. While these reports were probably somewhat exaggerated, there is no doubt that most primitive labor methods prevailed in the African regions.

In an effort to escape the wrath of the task-master, the African has found many ways to gather and congeal rubber rapidly. In some cases he fells the tree or vine and cuts the bark in great gashes; other times he climbs the tree and as he comes down, tears the bark with a sharp instrument. These methods give the most rubber in the shortest space of time. Sometimes salt is used as a coagulator. Salt rubbed into the incision, tends to coagulate the latex as it comes from the tree. The native then takes the strings, which have formed on the bark of the tree, and winds them into balls. These balls weigh as much as four or five pounds and are so bulky that the native has to lie on his back to wind them, supporting the ball in his hands on the pit of his stomach. Evaporation of the latex is hastened by the warmth of the negro's hands and a frequent application of salt serves as an antiseptic. In the opinion of many this is the most successful African method.

The African has also learned to boil the latex in order to coagulate it. Some of the natives, more advanced in civilization, have learned to use acetic acid. Another method is to catch the latex in a calabash vessel with a very small opening then add four or five times its bulk of water. The rubber then rises to the surface like cream, and after two or three days, the water can be drained off underneath, through the small opening which has been closed with a cork. When the water is removed the native takes the soft, half congealed rubber from the vessel and kneads it into balls. It is then cut into small squares in order to give it opportunity to further dry out and congeal.

This African method of gathering and coagulation resemble in many ways the handling of Guayule bushes, which grow in Mexico and Central America. In gathering this rubber, the whole shrub is cut down and ground into pulp. This pulp in then churned in water for hours. The fibre particles sink, and the rubber is skimmed off very much as you skim the cream from milk.

So far in our story of gathering methods, we have not mentioned plantation rubber. Plantation rubber is gathered and coagulated under ideal conditions. The plantations are operated and managed by men who are making a real study of the rubber industry and who realize that gathering methods are a big factor in the ultimate value of the product. Bending every effort toward putting out a clean, uniform-quality rubber, they have been repaid for their efforts by the good reputation which plantation rubber enjoys.

By cultivating the tree and tapping with care, nature permits the tree to be tapped more often than is possible in the wild state. The flow is steadier and the latex becomes better each year. Instead of making many small incisions as does the native, the planter makes one large incision and keeps the wound open.

Planters disagree as to the best method for making this incision. Some use the "Spiral Method," in which, as the name suggests, the wound is run spirally around the tree to the ground, very much the way a spring is built. Another one of the common methods is the "Herring Bone." By this method one long incision is made the full length of the trunk and short branch incisions connect with it at an angle of 45 degrees. The "Herring Bone" method is varied sometimes by planters who make the small branch incisions only on one side of the main incision. This is called the "Half Herring Bone."

In any method used, the cut extends just beneath the outer bark of the tree and the latex flows down the channel into a receptacle placed at the bottom of the trunk. When the latex stops flowing it is gathered into pails and taken to a building equipped for the purpose of coagulating. Here it is placed in large vats and congealed by the use of a weak acid. The rubber is then skimmed off, sheeted, dried and baled or boxed for shipment.

Because of these careful methods, plantation rubber is shipped to the market practically free from dirt and foreign matter. South American rubber averages about 15% waste, while African rubber runs anywhere from 30% to 60%. This is a big factor because rubber is purchased by the pound and no manufacturer likes the idea of paying anywhere from sixty cents to a dollar and a quarter a pound for dirt or bark which happens to get mixed with the rubber.

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CHAPTER SIX

Marketing

ALL rubber is marketed through brokers and dealers. A broker is a man who receives the rubber from the producer and sells it on a commission. A dealer is a man who buys rubber outright and takes a chance on being able to sell at a profit. The greatest rubber markets in the world, in the order of their importance, are London, Antwerp, New York, Manaos and Para. Practically all of the plantation rubber is handled through London. Most of this rubber is sold at auction. A list is made up of the various lots for sale and sent to all the men who might be interested in its purchase and if any of these men are in need of this grade of rubber, they place a sealed bid for the lots desired.

African rubbers are handled almost exclusively through Hamburg and Antwerp. Here the various kinds are received by valuation committees appointed by the government. After sufficient rubber is accumulated, a sale is advertised and any buyer may place a bid for as many lots as he cares to buy. There seems to be a growing tendency to handle some plantation rubber through the Antwerp market.

The New York market is controlled almost entirely by dealers who buy plantation rubber through London. New York dealers keep in very close touch with the rubber manufacturers of the country. As an illustration of how the deals are handled, a manufacturer may want twenty tons of "Wild Para" to be delivered within a certain time at a stipulated price per pound. If the New York dealer anticipates a rise in price and has not the stock on hand, he will buy for delivery at a future date to protect himself. If, on the other hand, he anticipates a decline in price, he will wait several days before purchasing the goods to fill the order.

Most of the rubber handled through Manaos and Para is sold through representatives and dealers in other parts of the world by the "aviadore." This takes place immediately after the cargo comes down the river. The transaction is merely an auction sale and the rubber is delivered to the highest bidder.

Only the largest manufacturers do any direct buying. The market is so changeable and its operation requires so much capital that manufacturers have found it cheaper to buy through dealers and brokers.

CHAPTER SEVEN

Inspection and Storage

TO MANY people the raw rubber inspection room of a large rubber plant presents the most interesting scene of the industry. The rubber in its various grades and varieties is received in almost countless forms, from the great hams of Pure Fine Para to the plantation crepe and sheets, pancakes, tails, balls, and a dozen other different forms, all representing a particular planter or tribe of Indians' ideas of an artistic or commercial way of putting up rubber.

We combine in this statement "the ideas of the native's artistic and commercial instincts" purposely. It may be his artistic temperament which leads him to shape up the raw product nicely, but we are sure that it is his commercial instinct which leads him to put rocks and stones, flour and sand, and perhaps his old overalls or shoes on the inside of the ball before it is made up. At any rate, the biscuits comprising shipments of rubber often produce so many articles of wearing apparel that inspectors unconsciously cut carefully into each biscuit for fear the native himself will turn up next. You see, raw rubber is purchased by the pound.

Rubber is purchased from sample, and like any article purchased in this way, the leeway for fraud is very great. This makes it necessary to have practically every pound of rubber that comes into a well organized plant inspected by experts to be sure that it is up to sample.

Once a shipment is accepted, it is usually stored under ground in order to insure a cool, dark place. You will remember that heat and light are two of the natural enemies of rubber.

In The B. F. Goodrich cellars there are at times over two million dollars' worth of raw rubber. An interesting point in connection with these cellars is, that they are connected with the Ohio canal and in case of fire the whole side of the canal can be razed and the cellars instantly flooded.

CHAPTER EIGHT

The Laboratory

THE alchemist of old who said words over water and changed it to gold, who changed hate to love and love to hate by the use of a powder; who restored youth and gave eternal life; performed legendary feats only a little more wonderful than the actual feats of the rubber chemist.

The B. F. Goodrich Company manufactures nearly 30,000 different rubber articles, each one to be used in a different service, each one of them requiring individual characteristics to meet the use to which it will be put. Some must be hard, some must be sort; some must stand the grind of abrasion; some must stand heat; some cold; some must be affected by acid; some must stand continuous pounding; others, a steady pressure.

The rubber chemist always works backwards. He is given a problem to solve in terms of what work the finished article must perform. He must say to himself, "this article which I desire to build must stand certain tests and perform certain kinds of work." Then from his knowledge of rubber and its compounds, he must experiment until he has found the exact combinations which, when vulcanized, will exactly meet the conditions under which the finished article must work. In making his experiment, he must choose between the combinations of more than 100 varieties of rubber and thousands of compounding ingredients.

Various combinations produce compounds of different characteristics. Add to a compound a foreign matter and the characteristics are changed again. For instance, in order to build an ink eraser it may be necessary to mix a half a dozen different kinds of rubber and a half dozen different compounds, such as ground glass, emery dust or some other gritty substance which will give the finished eraser the grit to tear just far enough into the paper to remove the ink.

Just as coffee growers mix certain grades of coffee to obtain a certain flavor, and just as tobacco manufacturers mix certain grades of tobacco to obtain a desired blend, so the rubber chemists are mixing their grades and compounds to reach a given result. Every large manufactory of rubber goods has its own chemists, its own experimental department, and the secrets of these departments are the very basis upon which success depends.

The compounding of rubber for use in making various articles resembles the make-up of a band. Just as each instrument in the band has its particular part to add to the tone of the whole, so each ingredient put into a rubber compound has its particular duty to perform in forming the characteristics of the whole.

If it were not for this a rubber tire or a water bottle made by one company would be exactly the same as the tire or water bottle made by any other concern. As it is, no two have the same compounds and a constant competition of quality results. One company may be able to build a first class article at a given price; another whose experience has gone farther in compounding rubber, may use a different combination of ingredients and produce an article equal, or greater in value, at half the cost. This accounts for the fact that it is not so much the price the user pays for a rubber article that counts as the name of the maker of the article.

In order that you may not get the idea that the rubber industry is all mystery, there are, of course a great many generally known facts concerning the characteristics of certain compounds. Just as every housewife knows that certain ingredients are used in making a loaf of bread, so every rubber concern knows from experience that certain ingredients are used in making certain articles; but just as certain house-wives can bake a better loaf of bread than their neighbors, certain manufacturers acquire from experience a sense of proportion which makes its articles stand out above the rest.

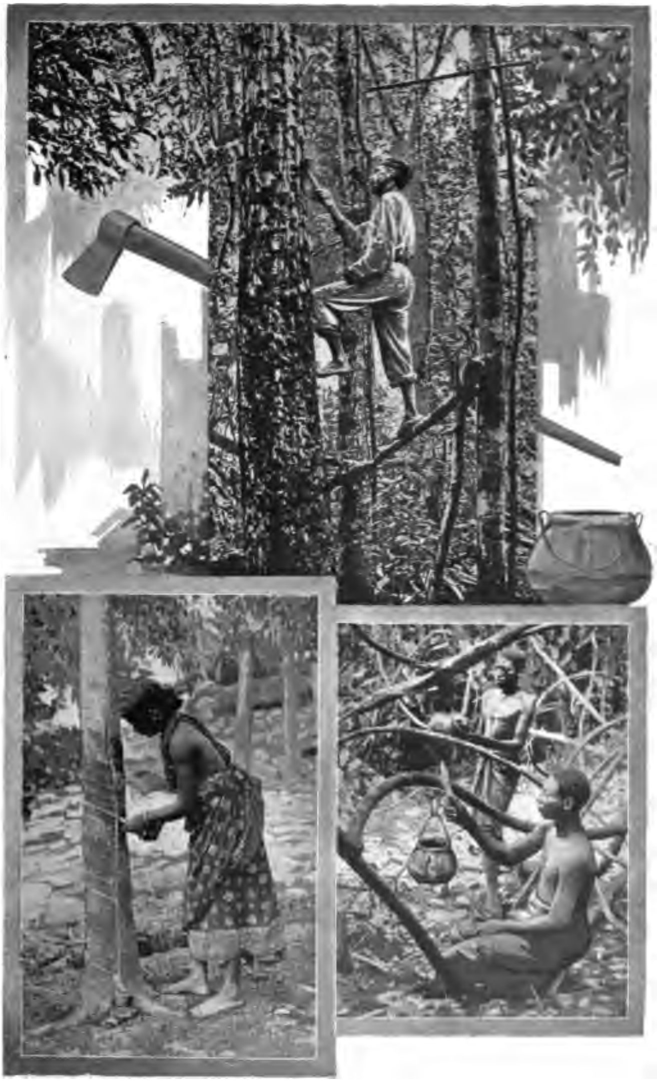
The experimental laboratories of a rubber factory remind us of a miniature circus. Ordinarily when we think of a rubber calender we think, through habit, of a mammoth machine, second in size only to the machines of the steel industry. When we think of a rubber mill or a washer we picture mammoth rolling pins. It is always with a start that we pause in the laboratories and see there these same mills in miniature, only a few inches high, all of them together forming, in a small space, a complete rubber factory, capable of handling each day, several pounds of rubber, instead of the several hundred tons which our mind has been trained to expect. Where the actual machines of the mill room make us stand still with awe, the machines of the experimental department fill us with curiosity and like "Budge and Toddie" in "Helen's Babies" we have an all-consuming desire to "see the wheels go round."

CHAPTER NINE

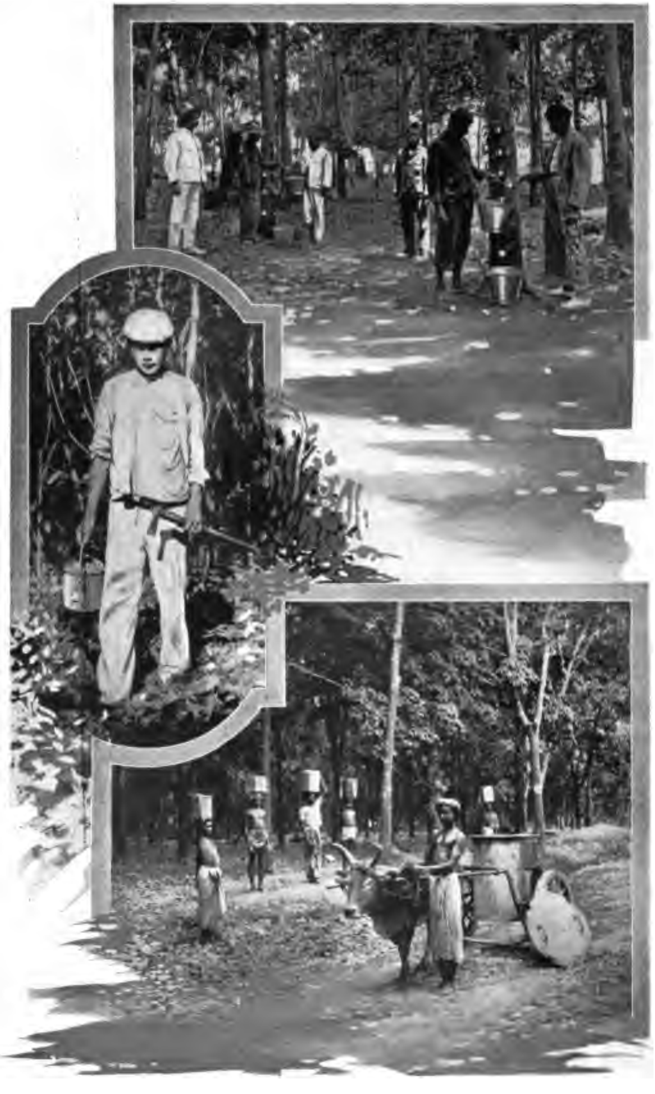
Compounding Ingredients

IN THE preceding chapter we told that there are a great many standard compounding ingredients, the general characteristics of which are understood by practically every manufacturer of rubber goods and surely by every rubber chemist. To go, however, into a detailed discussion of these materials would involve a book twice the size of this one. As an indication of the infancy of the rubber industry, our best authorities are gradually leaning toward the opinion that vulcanization is not as was generally supposed a chemical change, but merely a mechanical re-arrangement of molecules. When we consider that for years we have been working on the adverse theory, it shows that much is still to be learned about rubber.

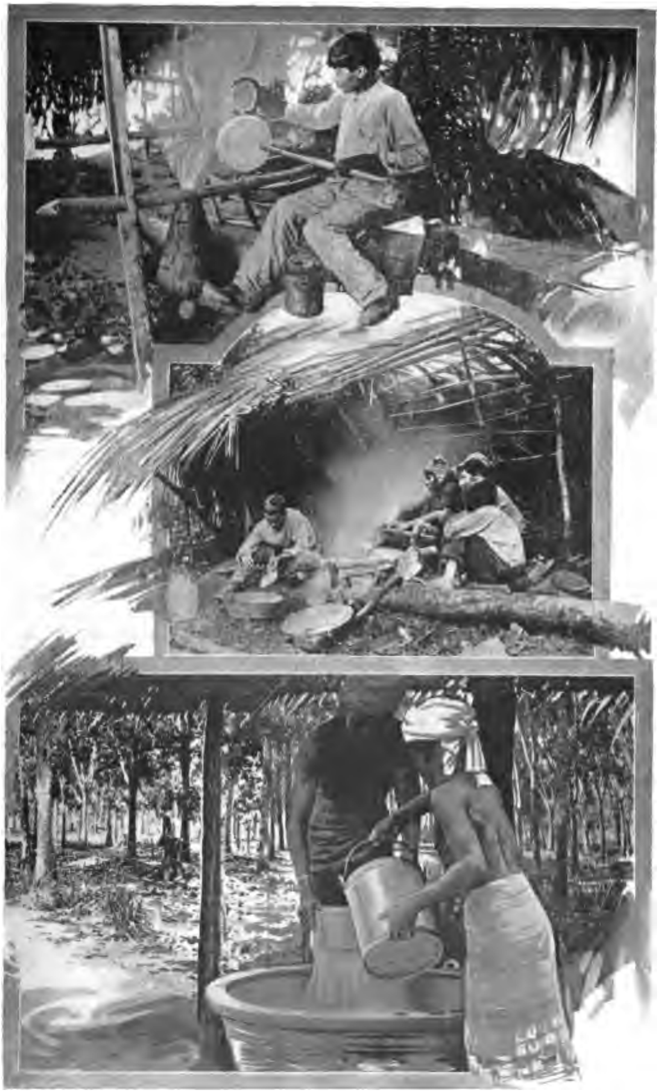
The most universally used of all compounds is Sulphur, which in some form is always necessary to effect Vulcanization. From among the many other ingredients that are employed by the expert compounder, those most frequently used are: Aluminite, asbestos, zinc oxide, litharge, white lead, barytes, whiting, china clay, fossil-flour, mica and talc. Less frequently used materials, which give the compound some distinct characteristic for some particular use, are: Asphalt, camphor, clay, chalk, charcoal, cork, earths of various kinds, emery, flint, gelatine, graphite, leather waste, lime, paraffin, pitch, coal, pumice, sawdust, shellac, sand, slate, soapstone, starch talc, tar, varnish and wheat



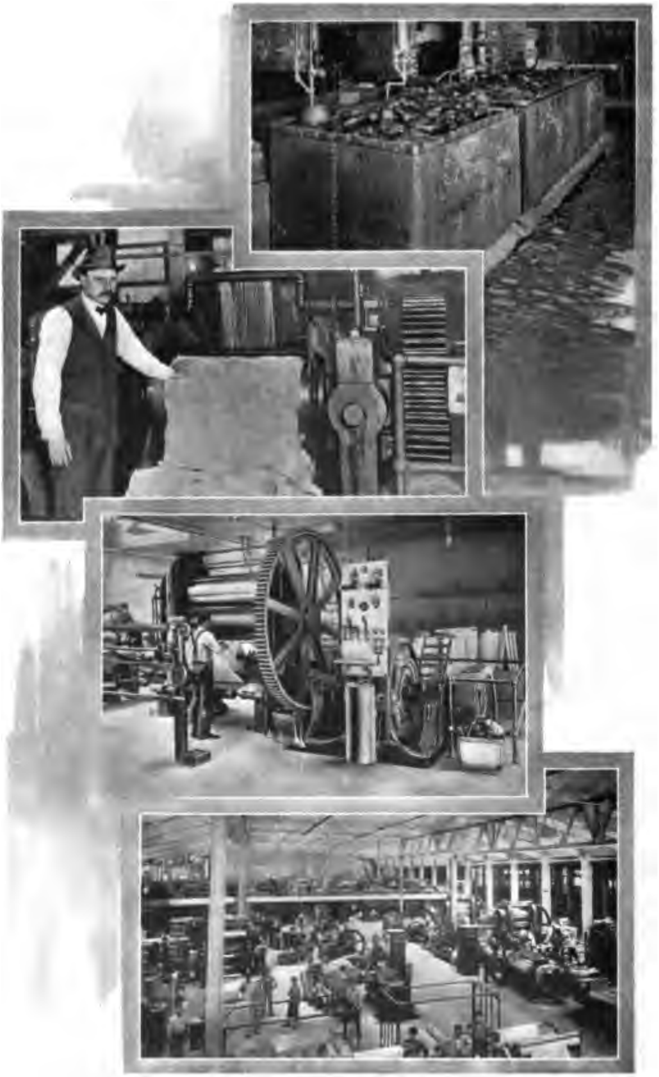
UPPER: CRUDE TAPPING METHODS USED ALONG THE AMAZON, BRAZIL.
LOWER LEFT: ON MALAY PLANTATIONS THE MORE SCIENTIFIC HERRING-BONE PROCESS IS EMPLOYED.
LOWER RIGHT: EXTRACTING LATEX FROM THE LANDOLPHIA VINE, PORTUGUESE, EAST AFRICA



UPPER: COLLECTING THE LATEX ON AN EAST INDIA RUBBER PLANTATION.
CENTER: SERINGUEIRO, OR BRAZILIAN RUBBER GATHERER.
LOWER: COLLECTING RUBBER ON THE MALAY PENINSULA



UPPER: BRAZILIAN COAGULATING RUBBER MILK WITH PALM-NUT SMOKE.
CENTER: A PERUVIAN-INDIAN RUBBER CAMP, THOUSANDS OF MILES UP THE AMAZON.
LOWER: IN CEYLON THEY FORCE COAGULATION BY ACETIC ACID.



UPPER RIGHT: GREAT WATER VATS FOR SOFTENING THE RUBBER "BISCUITS"
UPPER LEFT: A RUBBER-WASHING MACHINE.
CENTER: 'MID THE THUNDER OF THE GREAT CALENDERS.
LOWER: THE LARGEST MILL ROOM IN THE WORLD.

flour. As an illustration in this connection it may be of interest to note here that more than one rubber company prepares metallized rubber by mixing rubber, pulverized metallic lead, zinc and antimony and that in a similar fashion high pressure valve disks are made.

To render articles of clothing impervious to perspiration, wood cellulose has been mixed with rubber before vulcanizing. One pound of sulphur, one-fourth pound of camphor, and three-fourths pound of copal added to two pounds crude rubber will produce hard rubber or ebonite. A mixture of rubber and powdered cork has sometimes been used for floor covering and artificial whalebone can be produced by mixing rubber, ruby shellac, calcined magnesia, pentasulphide of antimony; this mixture which is kneaded and vulcanized, is also used for manufacturing gun stocks, elastic plates, and splints for surgical purposes. A mixture of rubber, powdered emery and sulphur will produce grinding compositions.

Hard rubber compound is often used to cover articles of metal that must be protected from rust, the metal being brushed over with a solution of rubber in benzine or petroleum, and then dusted with sulphur. Upon drying, this process is repeated, the article then being vulcanized.

To illustrate why the rubber compounder must take into consideration many things the story is told of how in 1876 there was considerable commotion in Germany on account of the death of a child, caused by poisoning from a rubber toy, imported from France. A poisonous pigment it seems had been used in the manufacture of this toy and so great was the effect of this error on the part of the French manufacturer that a law was passed in Germany forbidding the importation of French toys.

The French, of course, saw in this a move on the part of the Germans to efface competition. Perhaps they were right; at any rate, Germany practically controlled the rubber toy industry for a number of years afterward.

For the benefit of those who are inclined to seek specific detail concerning the characteristics of compounding ingredients, we are listing a number of them in the following pages, together with their uses. We must, however, take this occasion to point out that this list is very meager and that there are literally hundreds of minerals and other materials used to improve upon the basic material for particular purposes. Some of these are actually many times more expensive than raw rubber which fact in itself will give the reader some idea of the problems confronting the manufacturer.

Aluminum Flake	An inert heat resistant which toughens the rubber.
Asbestos	Low conductivity of heat makes it valuable in steam packings. Useful in fireproof materials.
Asphaltum	Softens compound, retards blooming, limits oxidization and increases density.
Atmido	Snow white filler. Low specific gravity. Indifferent to acids. Used in small proportions to increase strength and resiliency in soft rubber goods, also used in large proportions to make hard compounds and to resist superheated steam.
Barytes	Heavy white mineral. Inert. Increases resiliency and adds weight.
Blue Lead	Cheap filler. Produces a black color. Heavy and often displaces Barytes.

Burnt Umber	Dark brown, inert, good filler, often used in brown and maroon goods.
Charcoal	Made from bones. Absorbs odors and is used in packing to withstand heat.
Charcoal	Vegetable,—burned wood. It is used in certain vulcanite varnished and insulated wire compounds.
Cork	Used in Kamptulicon with rubber, as binding material. At one time used with rubber to make waterproof felt for hats. Also went into compound to resist heat.
Emery	Used in manufacturing vulcanite emery wheels. Also in other grinding and sharpening instruments such as hones and strops. Sometimes used to give the desired surface to blackboards.
Fire Clay	Mixed with rubber and dissolved in tar, oil and sulphur, forms a compound which, when applied to hot joints, cures at once.
Flour of Glass	A diaelectric for insulated wire compound. Used in certain packings.
French Chalk	Ground and sifted talc for rubber lubricant.
Fuller's Earth	Greenish or brownish and earthy. Used in making rubber type.
Infusional Earth	Wonderful non-conductor of heat and with asbestos is used in making boiler coverings. Increases rubber strength and resiliency but makes compound hard if used in quantity. Packing made with this material is practically indestructible in steam or water, oils and acids.

Lime	Air slacked. Used to neutralize water in a compound with tallow and rubber to make soft cements. Lime in any quantities in rubber is injurious since it leaves the stock porous and open to oxidization. When used in small quantities it combines with sulphur and prevents its continued action on the rubber but diminishes resiliency and increases hardness. Used in wire insulation. Rubber cures quicker when compounded with lime.
Litharge	A lead compound with specific gravity 9.35. Is valuable as a filler and also hastens vulcanization to a marked degree. All dry heat goods depend on it. Is used whenever possible in molded goods and the general mechanical line. Available for only dark or black effects.
Magnesia	Increases toughness and resiliency and is also used to increase hardness. Small quantities used to insulate wire, increasing diaelectric qualities.
Manganese	Used in cements.
Mica	Used in insulating and fire proof coverings.
Plumbago (*Graphite*)	Sometimes called black lead. More non-combustible than most ingredients and therefore used in rubber compounding to make articles capable of withstanding great heat. Inert, safe in any compound, perfect conductor of electricity and not affected by heat, acids, alkalies, or corrosive substances.

Powdered Coal	It is probably the cheapest ingredient in use today to make a jet black, semi-hard rubber. Such articles are sometimes made almost completely of powdered bituminous coal in which is incorporated only a very small per cent. of rubber.
Pumice Stone	Used in erasers as an abrasive agent.
Soapstone	Used in place of talc to keep rubber surfaces from sticking and also as an adulterant.
Starch	Used in artificial leather compounds.
Talc	Very largely used in preventing rubber surfaces from sticking together during manipulation or vulcanization. It is also used for dusting molds to prevent gum from sticking to the metal. Is sometimes used as a compounding ingredient.
Wheat Flour	Used in making matrices for rubber stamp work.
Whiting	Made from English chalk. Used more extensively in rubber compounding than any other material except sulphur. Increases resilience and hardness.

CHAPTER TEN

Cotton Fabrics

RUBBER we may state is distinctly of American origin, and it seems queer that, cotton also, the strongest and best fortifying agent ever used in rubber goods manufacture, should be almost entirely a product of the same new world. It is true we have mention of cotton as growing before the time of Christ, and that it was grown in a small way for years prior to the discovery of America. Columbus, however, on his second voyage (the same one on which he discovered rubber) found the Indian growing this useful fibre in large quantities, and his discovery marks the practical beginning of the cotton industry.

In the early experiments with rubber, almost every known fabric was tested and tried out in service. Silk, hemp, wool, linen, and even wood and paper fibre were experimented with. Silk was found to be effected by the process of vulcanization; hemp lacked elasticity; linen would not make the proper adhesion. Cotton was found, because of its better adaptability to the processes which rubber goods must undergo, particularly vulcanization, to be the logical fabric and accordingly is more generally used.

It must not be understood from this that cotton is the only fabric used in connection with the rubber industry today—for some of the finest grades of silk and wool are used in the manufacture of different types of sheeting. Cotton, however, is the popular fabric.

The best grade of cotton, for most rubber purposes, is long fibre Sea Island, but there is comparatively so little of this variety produced that almost the entire production is at present used in the manufacture of automobile tires. European manufacturers use an Egyptian cotton instead of the Sea Island.

The necessity for using cotton as a groundwork for so many rubber necessities is in many ways a handicap in the use of the article. For instance, the life of an automobile tire is limited at the present time to the life of the cotton carcass. More than half a century of study has taught the manufacturer how to control the life of rubber; but unfortunately, however, there is no known way to control the life or strength of cotton and as a result a tire is built to the strength of its cotton carcass rather than the durability of its rubber cover.

In the purchase of cotton cloth, the rubber manufacturer must take into consideration the purpose for which it is to be used. For instance, it would be an absurdity to use the same grade in a bicycle tire or a garden hose that is necessary to use in reinforcement of a mammoth conveyor belt or of an automobile tire. The difference in grades are determined by the weight of the fabric, the quality of the yarn, the number of plies, the twists per ply, and the number of threads to the inch.

Accordingly all cotton fabric, before it is used in rubber goods manufacture, must go through a series of tests. The more strenuous the work expected of the finished article, the more rigid the test is made. Fabric which is used in automobile tires, for instance, is subjected to practically every known test. The threads are counted, the length of the fibre is noted, and each thread must show a breaking strength of not less than ten pounds for the single yarn and small pieces are cut from the piece here and there and after being weighed, are subjected to chemical tests.

Fabric, after it has passed inspection, is "frictioned" or frictioned and "coated" as may be required. In the frictioning process, the fabric is run through between mammoth rollers which wipe into the fabric just as much rubber as it will hold. When thoroughly impregnated and a coating is desired, the fabric is taken to another machine, similar to the first, where in the coating process, a thin layer of rubber is laid upon the surface under such pressure that it in truth becomes a part of the stock which the frictioning machines have driven into the interstices of the fabric.

We may state by way of explanation that in making certain classes of goods, it is not necessary to coat the fabric while in others it is necessary to friction and coat only one side. Sometimes both sides are frictioned and only one side coated and frequently both sides are both frictioned and coated.

CHAPTER ELEVEN

Vulcanization

THE essential principle of rubber goods manufacture is bound up in one process, viz., that of vulcanization. Until Charles Goodyear, in the year 1839, discovered this process there was never any chance that this now useful substance might become commercially practical; and the story of this discovery to many is as full of interest as a tale from the Arabian Nights. Scientists had been working on the problem for many years. Charles Goodyear spent more than ten years of his life at its solution, his first successful efforts being in connection with a tanning process through the employment of acid solutions of metals. Letters of patent on this process were issued June 17, 1837. This tanning process was, however, far from effective.

At the same time that Goodyear was experimenting, another man, Nathaniel Hayward by name, of Woburn, Mass., was also very much interested with the problem of making rubber articles serviceable. The story goes, that one night after a long day in the study of rubber, Mr. Hayward dreamed that it could be vulcanized through the use of sulphur. We hesitate to vouch for the idea that the whole present-day rubber industry is the result of an almost spiritualistic revelation, but the fact remains that letters of patent, on the use of sulphur in connection with vulcanization, were granted to Mr. Hayward February 24, 1839. The effect of this discovery was so apparent that Charles Goodyear purchased Mr.

Hayward's patent rights and combining the process with his former one succeeded in perfecting an acid cure.

Goodyear did not, however, give up at this point and one day while making some further experiments he accidentally dropped some rubber containing sulphur upon a hot stove. He noticed that the rubber hardened with the heat and this convinced him that artificial heat could be made to take the place of acid. To prove his point he took the rubber which had been on the stove and nailed it to the side of his house that he might observe the effects upon it of weather conditions. It did resist the changes of temperature and the process of vulcanization had been discovered.

Briefly, this process of vulcanization which is the result of Goodyear's discovery provides that rubber mixed with sulphur in varying quantities and subjected to a suitable degree of heat produces a dependable material affected but slightly by ordinary changes of temperature and overcoming almost entirely the tendency of raw rubber to rot when exposed to light and air.

The two principal kinds of the vulcanized articles are known as hard and soft rubber. In vulcanizing the latter from 2½% to 10% sulphur is used and as the amount of sulphur is increased, the compound resulting becomes harder. The common hard rubber sometimes called Ebonite or Vulcanite, is made from a mixture of about two-thirds rubber and one-third sulphur.

What actually happens to the rubber during this process of vulcanization we do not know and manufacturers use the process without fully understanding it, just as the electrician uses laws without knowing why they are true. A number of theories have been advanced and while all of them are mere theories, unproven, general belief seems now to indicate that the change effected is physical and not chemical in nature.

As he proceeds through the chapters of this book, the reader will see how the process of vulcanization affects the various articles described and also how the principle of vulcanization applies in the building of each article.

CHAPTER TWELVE

Manufacturing Processes

THERE is a wide spread impression that rubber goods are manufactured by pouring melted material into molds, very much after the manner in which articles of cast iron are made. This is a mistaken idea for rubber is not poured, but is molded from dough, hand made from sheets or dipped.

A rubber factory is nothing more or less than a "Bake Shop," for just as in a bakery, the operations are divided into three heads: (1) the mixing or compounding, (2) molding into the desired shape, (3) "Curing" or "Baking." The base of the baking industry is flour, the base of the rubber industry is rubber. When a cook bakes biscuits she adds to the flour dough, a combination of baking powder, salt and shortening. If she wants to make a pie dough she uses the same base of flour, increases the shortening and leaves out the baking powder. So it is in the making of rubber goods. We use rubber as a base for everything. To make a hot water bottle, however, we must use different ingredients than are used in making a pipe stem, or a conveyor belt, or a tire, or a boot. Many times we adopt the principle on which buckwheat cakes are made, and mix two or three or even a dozen different kinds of rubber, just as your mother mixes two kinds of flour to take the "twang" out, and yet leave the buckwheat flavor in.

When the compound, or "dough" is ready, we mold it into the desired shape, just as your mother rolls out the pie dough, or cuts the biscuits with the top of the baking powder can. You will remember that rubber, kneaded under slight heat loses its elasticity.

Once the compound is mixed and molded or cut into the approximate shape of the article, it is put into cavity molds, just as a cake is put into a pan, and these are then put into vulcanizers and "cured" the same as the pie is put into the oven and baked. In the process of "curing" there is a divergence from our comparison with the baking industry, in that rubber, for many purposes, must be cured under pressure, and the method and thoroughness of applying this pressure determines, to a great extent, the value of the finished product.

There is also this further divergence from the baking industry in that the old quotation, "You can't eat your cake and have it, too" does not hold good since a rubber article, worn out, can be reclaimed and used over again —in a different purpose article.

As raw rubber is taken from the storehouse it is first thrown into softening vats and soaked in hot water for a period of several hours. When soft and more workable it is put on "cracking" mills which chew the rubber into flat sheets more easily handled than the ordinary biscuits or bales of plantation crepe. While being "cracked," cold water is run over it constantly for two reasons; first, the water partially washes out any dirt and foreign matter which has lodged in the rubber; second, if it were not for the cold water, the rubber being torn to pieces in the jaws of the mill would generate heat which would tend to destroy its own life. When the rubber has been cracked it passes through a series of washing mills where again it is ground between the jaws of rollers and thoroughly washed in cold water which flows over the mass during the entire process.

After the rubber has been washed it is sent to the drying rooms where it is left until the moisture in it has been reduced to a minimum which takes from five hours to eight days, in a temperature approximating 100 degrees depending upon the methods used.

After it is thoroughly dried, the rubber is taken to the mixing or milling room and once again put into the mammoth jaws of a mill resembling two great rolling pins. There under slight heat, it is kneaded over and over until it loses its elasticity. It then becomes very much like putty and is mixed with the compounding ingredients, after which it is ready to be molded into any desired shape, and vulcanized into the finished article.

Thus you see, up to a determined point in the manufacture of rubber goods all the various material goes through practically the same process. The divergence comes at the time of mixing the compounding ingredients and up until that step the rubber might be used for many articles other than those for which it is being prepared.

Dipped goods, which represent but a small per cent. of the articles manufactured, are made by plunging mandrels into rubber which has been "cut" into a cement by the use of gasoline or benzine. Very thin articles such as surgeons' gloves, toy balloons, and whistle bulbs, are made by this method. To make a glove, the mandrel is first cut exactly the shape of the hand over which the glove is to fit. This is dipped into a rubber solution and allowed to dry, then dipped again and any thickness can be obtained by increasing the number of dippings.

In order that our readers may understand more clearly methods followed in the manufacture of a general line of rubber articles, we are attempting in the following chapters, to give short yet clear descriptions of the manufacturing processes for the more well known products. We have attempted to pick out such articles as will typify various methods of manufacture and before the reader has progressed very far, he will discover that the general principles are the same and that each article owes its distinction to some detail of machinery or method of applying the molded principle.

CHAPTER THIRTEEN

Boots and Shoes

THERE is always a tendency in speaking or writing about rubber boot and overshoe manufacture to dwell upon the romance of the industry and to describe how the Indian of South America, smeared layer after layer of rubber latex over his feet letting it dry in the sun, every time he felt that he needed a new pair of shoes. At this point we might pause to note that there has been considerable change in the manufacture of rubber shoes since the days of the Indian.

At present there are two methods of making in vogue, one of them, the Hipress method, developed by The B. F. Goodrich Company, has truly revolutionized the manufacture of heavy rubber footwear.

All shoes are built from "Frictioned," or rubber coated cloth, cut very much as are the pieces of a dress, these being cemented together over a wooden or metal last exactly the shape of the inside of the finished boot. Over this cloth background or "carcass", is built an outer covering of rubber. The finished boot is dipped into a preserving varnish which gives it durability as well as the luster always noticeable on the average black "rubber." The boot or shoe, left on the mold, is then cured, inspected, and prepared for the market. While by the process formerly in vogue all rubber footwear was cured in open heat, the new method for heavy footwear, the Goodrich "Hipress" method, varies from this in that instead of being cured in open heat, it is accomplished under pressure after the same manner as the automobile tire. In fact, the "Hipress" boot is made of practically the same compound as the Goodrich automobile tire. The patents on this method are held by The B. F. Goodrich Company, and the compounds and methods of manufacture are held as one of the most valuable secrets of the industry.

CHAPTER FOURTEEN

Belting

RUBBER belting is the standard transmission belt; but other and newer applications have become important. Millions of dollars worth of rubber belting is used every year for the transportation of materials such as coal, coke, stone, ore, cement, vegetables, automobile parts, pills, pins, etc., and for many other purposes. Transmission Belts are familiar to every one and Conveyor Belts are becoming commoner daily, having established the fact that a belt conveyor is the most economical carrier of bulk material for short and moderate distances. But, Elevator Belts, with steel buckets riveted to the outer surface, find their application chiefly in the mining industry and in grain elevators.

Every belting application has been studied carefully by our engineers and the three general classes have each been subdivided into several brands designed particularly to meet the demands of a certain class of work. We have special belts for paper mills, saw mills, oil wells, coke conveyors, coal conveyors, ore elevators, grain elevators, railroad axle lighting generators, etc., as well as for dehairing animals and polishing jewelry. Each brand is individual and distinctly the result of special development.

Cotton fabric gives the belt its tensile strength and body, which are very important; but it is the frictionless insulation around each thread, the strong enduring friction, or elastic bond, that holds the plies together, the moisture proof wear resisting envelope or cover that protects the cotton from the elements, heat, oil, etc.—it is rubber that has caused rubber belts to predominate the vast belting industry eclipsing in importance, efficiency, and use those made of other materials.

Goodrich rubber belting is made by folding and rolling specially woven frictioned or impregnated cotton fabric, layer upon layer until the desired body and necessary strength have been built up. A thin cover of rubber may or may not be applied. After the belt has been completed it is placed in a press or vulcanizer where it is subjected under tension or while stretched to a certain predetermined temperature for a given length of time. Our manufacturing methods produce a belt of such uniformity and quality that after nearly fifty years we are still the leading makers of this rubber product.

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CHAPTER FIFTEEN

Automobile Tires

JUST as the man who invented shoes paved the world with leather, so the inventors of automobile tires have paved the world with rubber and the development of the automobile has been made possible only through the aid of the automobile tire.

Could Mr. Symington, of London, have had the use of a modern pneumatic automobile tire, or even the use of a solid truck tire when he built his first steam coach in 1786, there is but little doubt but that the automobile industry would have continued to this day without interruption.

Could Mr. Oliver Evans of Newport, Delaware, have found some way to keep his coach from racking itself to pieces, he would undoubtedly have followed out the patent rights granted him by the states of Maryland and Pennsylvania in 1786, to build and operate steam coaches on the roads of these two states. Could the first American car, built in 1805, have been made safe and comfortable with rubber tires it probably would have developed into something other than a curiosity. The name of this car was the "Orcutor Amphibulous," and it could be used in the sea as well as on land.

In 1835, Dr. Church of London, built a coach which ran thirty-five miles per hour with forty passengers. It fell to pieces at the end of the first trip, just one hour long. The framework could not stand the jolt and jar of the road. Mr. Hancock, of London, operated six coach lines in 1840, but they proved so uncomfortable both to the people riding and to the neighborhood through which they had to pass, that the courts denied these "devil wagons" the use of the roads and the automobile industry was killed in its infancy—through the lack of rubber tires.

These early machines were all operated by steam; they were clumsy and noisy and dirty but the modern development of the steam driven automobile shows what science could have accomplished many years ago, were it not for the lack of a modern rubber tire.

The framework or "Carcass" of the modern tire is built of long fibre "Sea Island" cotton in the form of fabric or cords and the strength of the tire lies mainly in this cotton framework. The rubber serves three purposes: (1) to bind the plies of cotton fabric or cord together, (2) to protect the cotton from moisture and (3) to protect the carcass from the abrasion of the road.

In building an automobile tire the cotton fabric is first frictioned with rubber and coated on one or both sides with an additional thin layer of high grade gum. The fabric is then cut on the bias into strips just wide enough to fit over an iron core which is the exact size of the inside of the tire. These strips are spliced together, wound around the core in several thicknesses and stretched and rolled thoroughly into place.

Our readers have perhaps heard that some are machine made while others hand made but may not know that the difference between the two lies in the method of winding these strips of fabric around the core. This work in all shops was formerly done by hand, but of late years the machine has taken the place of hand work in the more modern factories. Since the tire depends for its wearing qualities on the evenness with which the various layers of fabric are applied and the hand built tire was so variable and so dependent upon the character of the builder that it was never entirely a success. Some humorist has put it, "If, under the hand built method, the builder has been on a 'tear' the night before, the tire would have its little blow-out soon or later." Another man laughed, "The life of the hand built tire depends very materially on how the builder's wife felt at breakfast."

The machine built tire permits of no variance in the tension. Every ply is laid in exactly the right position with precisely the same number of pounds pressure and thus the chance of variation is reduced to the minimum.

The number of plies desirable in the various sized tires has been the subject of much controversy in the last few years. It is generally agreed, however, that the fewest possible number that will give the tire sufficient strength to withstand the strain of its work is the best tire in the end. This statement may sound contradictory until we stop to remember that too many plies of fabric create internal friction between themselves and since friction creates heat and heat is one of the enemies of rubber—a tire can just as easily be too thick as it can be too thin. In fact, theoretically, the ideal tire would contain but one ply of fabric.

A simple test of this is to put your hand on an automobile tire immediately following a fast run on a summer day. You will find that the tire is very hot. The thicker the tire, the hotter it will be—while the Silvertown Tire, with but two layers of cord in place of the five or six layers of fabric, remains comparatively cool through a five hundred mile race.

The thickness of the rubber tread is not so important as is generally supposed, for the tread is nothing more or less than a rubber band placed on the outside to protect the fabric. If a poor quality of compound is used, a thick tread is necessary, and inversely the better the quality used, the thinner the tread can be. Such a stock should be just thick enough to last the length of the life of the fabric and if the tread wears off while the fabric is still good, the tire is unbalanced. This statement is at variance with the popular belief that any tire that wears down to the fabric without a blow-out is a good tire. Experience has taught the rubber manufacturer how to control the life of the tread but the same manufacturer has no control, whatever, over the life of the fabric. As a result the best tires are the ones wherein the manufacturer has solved the secret of having the tread and the carcass wear out at a uniform rate.

It is interesting to note, as a matter of history, that the first automobile tire made in America, which was built by The B. F. Goodrich Company, contained sixteen plies of fabric and a tread one and one-fourth inches thick. One of the older experimental men in speaking of this tire said: "That was the finest tire ever built in America but it wouldn't run five hundred miles."

From the fabric laying machine the carcass is taken to the building room where the "beads" are covered, the "breaker strip" added and then covered with rubber side walls and a rubber tread which has been built up previously from thin layers of calendered stock. The beads are the parts at the edge which holds the tire in place upon the rim. The breaker strip is a coarse fabric strip laid between the carcass and the tread, to help protect the fabric of the carcass from the impact of road obstructions and inequalities. In order to give the breaker strip free play, there is a strip of pure rubber laid between it and the carcass which strip is known as the "cushion" gum or "multiply."

Now that the tire is built, it is put into a mold of two parts and these parts are forced together by hydraulic pressure, pressing the soft gum of the tread into the non-skid pattern which has been milled on the interior of the mold. The molds containing the tires are at the same time placed in large retorts or "vulcanizers" and heated to a temperature of about 245 degrees Fahrenheit for a period varying from one to three hours. When the cure is complete the tire is taken out of the vulcanizer, the core is removed, the tire is inspected, cleaned and wrapped. It is then ready for the market.

The method just described is known as the "unit mold single cure," by which the tire is vulcanized but once and comes out of the mold a single mass of rubber and fabric made up of no parts which are in danger of separating later through fault of cure.

There are several other methods of vulcanizing. The most common ones are the "Double Wrapped Cure" and the "Single Wrapped Cure." The former method varies from the latter method in that both the carcass and the tread are semi-cured before they are put together. Let it be noted that these methods are growing less important every day and even the manufacturers who have been advertising them as features are marketing "Single Unit Cure" tires with a view, we suspect, to changing their whole scheme at the earliest possible moment.

The "Double Cure" method has proved impractical because the two parts are liable to separate in actual service later and in addition to being subject to this danger is so expensive without attendant benefits in results, that mere economy demands its discontinuance.

The Cord tire which is in all its variations a development of the Palmer-Web tire was introduced into this country by The B. F. Goodrich Company and since has become extremely popular and accordingly much exploited. The Palmer-Web, i. e., the original design, while undoubtedly the fastest tire ever built was not able to stand hard road service and was discontinued after a few years to be taken up later in modified construction.

The Silvertown, the first and so far the only real Cord tire, was first built in Silvertown, England, under the name "Palmer Cord." The patent rights for America were purchased by The B. F. Goodrich Company and the tire is now being built under the name "Silvertown." The "Silvertown" is constructed of two layers of cord running at an angle of 45 degrees round the tire, each cord approximately one-quarter inch in diameter. The Palmer-Web tire is built up the same as an ordinary fabric tire except the fabric used is made up of threads all running one way, i. e., all warp, no weave fabric. In building the "Silvertown" tire, the cords are laid on the mold by machine and in the finished tire, each cord is a free agent, a layer of rubber between each cord keeping any two from touching each other. The "Silvertown" principles are thoroughly covered by patents, and have no imitators while the patents on the Palmer-Web have expired which accounts for the number of tires put on the market, since the time of its expiration, using this principle, but advertised and sold under the name "Cord."

Among the advantages of the cabled Cord tire are decreased gasoline consumption, increased power, quick starting, long coasting range and easy riding.

The solid tire is designed primarily for use on heavy trucks, and the mechanism of the trucks is built so as to withstand the continual jarring which must necessarily come through the use of such a tire. The pleasure car, however, with its comparatively delicate mechanism built for speed and comfort, must have tire resiliency never obtained in a durable solid tire.

There have been hundreds of inventions placed upon the market bordering upon the solid tire idea intended for pleasure car use, but none have been successful, for very obvious reasons. In a pneumatic tire the impact of the striking blow in driving is distributed evenly throughout the tire by reason of its air cushion, while in the solid type this force is confined to a surface only slightly larger than that which is in contact with the road. To illustrate, the average 30 H. P. automobile going thirty miles an hour and striking a brick, strikes a blow equal to 250 pounds dropped 100 feet. As long as tires are made of rubber and fabric, we doubt whether or not this blow can be successfully received in any other way than by having it distributed throughout the whole tire by the use of air.

CHAPTER SIXTEEN

Tennis Balls

IF REMOVED, in its four equal sections, the peel from an orange will give an idea of the shape of the sections of rubber that are used in building a tennis ball. These four sections are put together by hand and on the inside of the globe thus built there is first attached a small round disk of "green" or uncompounded rubber. This disk, before we get through, will probably answer a question that always bothers everyone, "How do they get the air pressure inside of a tennis ball?"

While the "center" is being built a few drops of water are placed inside by means of an ordinary eye dropper. The doughy ball is then put into a cavity mold and subjected to heat during which process this water inside turns to steam and exerts the necessary pressure to balloon the ball against the side of the hollow mold while the cure is being accomplished. After the cured ball is taken from this mold, a hollow needle is inserted at exactly the spot over the disk on the inside. This disk, you will recall, is "green" or raw rubber, without even the addition of sulphur, and consequently does not cure. Air is shot through the needle until the required pressure is obtained, when as the needle is drawn out, the uncured disk on the inside closes over the hole acting as a valve.

Now that we have the tennis ball center complete, it is covered with flannel, cemented and sewed. It is then ironed on a special machine in order to give it the smooth appearance which is desired by all in the finished product.

CHAPTER SEVENTEEN

Molded Goods

WE FIND the processes of rubber manufacture in their purest elementary form in the construction of those articles coming under the category of molded goods. The majority of articles which we are manufacturing in this department are built entirely of rubber, i. e., without fabric reinforcement, and in order to describe the method it is only necessary to call to attention our previous comparison of rubber manufacturing to the baking industry. When the rubber has been properly compounded, machines cut the raw material into segments of nearly the same shape as the finished article. Each of these segments is tested on scales and must weigh exactly that amount which will fill the mold into which it is to be placed. They are then pressed into the molds by hydraulic pressure and cured.

Making rubber heels, for instance, reminds us of making biscuits in that a long sheet of rubber or dough is run out, the heels are shaped just as biscuits are cut. They are then put in a mold and cured, just as the biscuits are put into the oven and baked, with the exception that the heels must be cured under pressure.

By slotting the molds properly, articles can be built of part rubber and part metal. By way of illustration we mention the rubber headed tack. In building these, the tack is first placed in a slot in the mold and the rubber pressed around it and cured.

CHAPTER EIGHTEEN

Hard Rubber

AFTER having become familiar with the processes of manufacture used in making other classes of goods, the principle divergence from the usual practices in making hard rubber is easily explainable. The main variation between the processes for making molded goods, soft rubber and hard rubber articles is, as somewhere previously mentioned, the amount of sulphur used in the vulcanization and duration of the cure. It will be remembered that one-third of the compound used for hard rubber is sulphur, and therefore the logical conclusion must be that hard rubber articles will necessarily be cured much longer than soft products.

A further distinction between molded goods of soft rubber and those made from a hard composition lies in the finishing process. In most cases the soft molded article is considered complete when the cure is effected, except for the removing of the mold marks. However, in making hard rubber goods, this is not always the case for a great many articles of this class are molded and vulcanized into approximately the shape of the finished article and afterwards put on lathes and cut to the exact shape required. Hard rubber will take a very high polish and this is a very important characteristic since many articles made of hard rubber, such as combs, chains, bracelets, boxes, fountain pens, paper knives, knife handles and buttons, are used as a substitute for material such as bone, horn and ivory. These are all more or less ornamental and must be made in an attractive form.

In the last few years, the growth of the electric storage battery has been a big factor in the development of the hard rubber industry. The jars for the smallest batteries are molded. Most of them, however, are built by hand over forms and cured by a special process in an ordinary open steam vulcanizer.

CHAPTER NINETEEN

Clothing

SINCE time immemorial men have been attempting to devise more satisfactory waterproof garments, and literally thousands of patents have been issued in Europe and the United States covering processes of waterproofing. It is therefore very natural that the first practical use which occurred to the scientists of Europe for rubber should have been the rubberizing of cloth. All early experimenters seem to have this one goal in mind and they were on the right track, for today the only generally satisfactory method of waterproofing cloth is by rubberization. Rubberized waterproof clothing is fashioned from patterns somewhat similar to clothing of the ordinary variety although it is made from cloth which has previously been rubberized.

Briefly, the method of preparing the cloth for Waterproof Clothing is to first run a "skim coating" of rubber over one surface. This coating can be so distributed that as little as one-quarter of an ounce of rubber can be put on to one yard of cloth, but this process is repeated until the greater thickness of rubber is secured. The coating is then cured by "steam heat" in specially constructed vulcanizers or by acid. Some waterproof coats are made of prevulcanized cloth while others—rubber surface—are built first and cured afterwards.

There are three methods used for vulcanizing the rubberized cloth for clothing. One is known as the "Dry Heat Cure"; another as the "Steam Cure"; while the third is known as the "Acid Cure." Needless to say the acid process is not used by The B. F. Goodrich Company.

The "Acid" cure consists in passing the cloth through a solution of sulphur chloride in carbon bi-sulphide or by hanging the rubberized cloth in closed rooms which are filled with a vapor of sulphur chloride. "Acid" or vapor cured clothing made in this country has not been entirely satisfactory, because, for some reason or other, the method of treatment has been so handled that it has resulted in a surface which deteriorates and leaves the coat ugly in appearance and worthless for protection against rain. The raincoat markets in both Europe and America were once flooded with these cheap garments, and the general public, which has no means of knowing the value of rubber goods, has been literally cheated out of millions of dollars invested in worthless "Acid Cured" Waterproof Clothing.

The best grades of cloth surfaced waterproof garments are made water repellant as well as water proof. In other words, the cloth is so treated that it not only turns water, but prevents water from soaking into the fiber. Every sort of cloth cannot be waterproofed successfully, but it is possible to rubberize most cloth without disturbing its color or design, providing the rubber compound contains the proper minerals.

CHAPTER TWENTY

Water Bottles

THE process of manufacturing rubber water bottles has undergone a radical change in the last few years. Up until a short time ago, all were made by hand from rubber which had been semi-cured during the calendering process, receiving their final cure by open steam in beds of soapstone, whereas today they are nearly all of the one piece molded variety.

Next to compounding, the most important factor in the building of a hand-made bottle is the seam. The best hand-made bottles are seamed with a strip of "green" or uncompounded rubber underneath the straps; which strip remains uncured making it almost impossible for the bottle to leak at the seam.

Rubber itself is, however, so inconsistent and so variable that hand-made articles, subjected as they are to the dangers of the human element, have not proven as satisfactory as articles which are made by machine, where every operation is a practical certainty. The molded bottle has this advantage and another in that there are no seams to open and endanger its life.

In building the molded bottle, sheets of rubber are placed around a core in a mold and cured under pressure; the edges being reinforced so that the danger of cracking is eliminated. The compound used in The Goodrich molded variety is so strong that after the bottle is cured, the rubber will resist without injury to itself a pull of over one ton.

CHAPTER TWENTY-ONE

Hose

FEW have ever stopped to realize that a distinct type of hose must be manufactured for practically each of the various uses for which rubber hose is employed. The common varieties are water hose, steam hose, pneumatic hose, suction hose, fire hose and gasoline hose.

While there is some difference in the mechanical methods of construction of these various classes the main difference is in the compounds. The rubber used in each class is so constituted that it withstands the work for which it is intended. A piece of garden hose has been known to last over thirty years but if this same length were to be used for gasoline, or oil, or even steam, it would last only a few days.

Common garden hose is made in two ways; wrapped and braided. In the manufacture of both, a rubber tube is first run from a "sausage" or tubing machine from this point the methods vary. In making the wrapped hose the tube is placed over a mandrel and after being wrapped with a number of layers of fabric and rubber, is cured in live steam.

In making reel hose the tube is slightly inflated with air and run through a machine which braids a cotton jacket over it, very much after the manner ribbons are braided on a May Pole. Any desired number of plies can be thus laid one over the other with rubber insulation interposed. The completed hose is then cured in molds. This braided type known as "reel hose" is the more popular because it can be made in any length and will not kink when put into service, whereas the wrapped duck type can only be made in 50 feet lengths and tends to kink when bent sharply.

The two methods of building garden hose, just described, illustrate the two principles upon which every type of hose is built. Types of hose, in addition to differing in compounds, differ in the protective measures employed to preserve it when put into actual service. Some types have a woven cotton cover; this construction usually being designated by the term, "Cotton Rubber Lined." Some types have a wire wound on the outside, others are protected by marline windings, while still others are protected by wire or cable imbedded in the walls.

All hose is built under very rigid inspection. This is particularly true of fire hose, for while a defect in garden hose may mean only a wetting for the gardener, the same sort of defect in a length of fire or pneumatic hose, might mean a hundred lives jeopardized.

CHAPTER TWENTY-TWO

The World's Largest Rubber Factory

THE B. F. Goodrich Company which operates the largest rubber factory in the world, was founded by Dr. Benjamin Franklin Goodrich, after whom it was named, in the year 1870 and was the first of the highly successful manufacturers of a general line of rubber goods in America. While there are other factories which are older, their business has been confined to one line rather than to the manufacture of a general line of rubber goods as has ours.

The B. F. Goodrich Company has been and is, the backbone of the Rubber industry. Many realize this fact from their observations of our business methods, but to describe the Goodrich factories to one who has never seen them would be an impossibility. Perhaps the best graphic picture of this institution can be formed from the statement that The B. F. Goodrich Company contributes one-sixth of all the taxes of the county in which it is located, although in this same county (Summit), there are located thirty-one other rubber factories and a number of very large manufacturing concerns in other lines. An interesting comparison is also shown by the fact that of the 150,000 people in the city of Akron, 20,000 of them are employed by The B. F. Goodrich Company and counting four to a family, the Goodrich plant alone on this basis would support a city of nearly 80,000. To base our visualization upon figures:—The Goodrich plant is made up of more than 59 buildings grouped closely together and in one of these alone you could put twenty-eight football fields and still have room for the bleachers. If you were to follow the boundaries of the factory property, you would walk 3.8 miles to complete the circle. The buildings cover 63 acres and in themselves constitute a group of such size that it requires the services of two complete fire departments in addition to the Akron city protection, and these departments in case of necessity can throw 9,000 gallons of water per minute without calling for municipal aid. In our "little city," we use more than 22,000 electric lights, 62 elevators, and have several completely equipped emergency hospitals.

The production figures of the Goodrich plant are so large that they are beyond comprehension even to one who is working with them constantly. All in a day's work we mix more than 350,000 pounds of rubber compound, manufacture more than 60 miles of insulated wire, 15 miles of rubber hose, 60,000 pairs rubber heels, 15,000 pairs of boots and shoes, 4,000 water bottles, 18,000 battery jars, 11,000 golf balls, nearly a ton of rubber bands, 7,000 bulbs, 20,000 automobile tires, not to mention some 30,000 different articles on a somewhat lesser scale.

Even as this is written the size represented by these statistics is increasing at a rate which makes our statement but mildly significant of the bigness of the Goodrich factories.

MAY 19 1926

CHAPTER TWENTY-THREE

The Future of the Rubber Industry

TO THE unbeliever of twenty-five years ago, who was used to the clatter of hoofs and the rattle of wagons, it was a long step to the noiseless rubber-tired, smooth running vehicles of today. This same unbeliever, with his hob-nailed boots would have laughed derisively at the idea of a thin rubber sole which would outwear his hob-nails. Rubber, to this man, was a curiosity. A little of it used in a garden hose was perhaps a good thing, but as he would have told you, "You can get too much of a good thing."

In the light of past developments, however, it is not such a long stretch to the time when the rubber tire will meet a rubber pavement and the rubber sole will walk on a rubber sidewalk. This time, in fact, is nearer than we think. Experiments in rubber paving have now been carried on for more than twenty years and they have proven satisfactory from a mechanical standpoint. Cost is the only barrier at present—and the price of rubber is going down, while the price of other materials is going up.

Men who ought to know, say that we may look for universal use of rubber furniture, flooring, and roofing in the near future. Our best buildings, even today, are being floored with rubber and it is easy to imagine roofing and furnishing the same building with the same substance just as wood has served in the past.

In addition to the fact, that raw rubber is going down in price, factory methods and volume production are affecting cost materially. Rubber articles today sell for less than one-third of what they did ten years ago. Some day it will be cheaper to manufacture many articles from rubber than it will be to make the same things of wood or other material.

Europe has already reached the stage where many common articles formerly made from wood are now made from a substitute. In many places they are using celluloid because their experience with this material is greater than their experience with rubber. In America, however, we are more familiar with rubber and this makes rubber the natural substitute.

This transition from wood, iron and stone to rubber will not be effected in a day. It will take years and has in fact just started. But today more than 50,000 articles are made wholly or in part from rubber. Ten years from now that number will undoubtedly be doubled, perhaps tripled. Think of the thousands of articles now made of wood and other materials which are bound to reach a prohibitive price under present conditions.

For example: There are used in the United States every year about one hundred million broom handles. In a very few years, if conditions progress, they can be made from reclaimed rubber cheaper than from wood. We can close our eyes and see an advertising campaign for a flexible broom handle, showing the old way—the woman with the tired back, and the new way—let the broom handle do the work.

This has been the history of the rubber articles which are used today. We now have rubber penholders, stopples, sponges, buttons, hair pins, heels, soles, combs, buckets, tubes, pouches, and literally hundreds of everyday necessaries and luxuries of life which not long ago were made from other materials.

Today there is no people, no industry, no phase of life that is not affected by rubber. Take rubber from the world suddenly and civilization would turn back a thousand years, yet so marvelous has been its growth that the whole rubber industry has been developed in less than a century and even now men who know the most about the nature and application of rubber, marvel at the slight knowledge we really have concerning it. The rubber industry is so much in its infancy that we must guess at most things and dream of results before they are attained. Rubber is so fascinating, so variable in its characteristics, so alluring in its possibilities—the field is so wide, and the industry so young—that the rubber dreamer's dream of today is a reality tomorrow.

IT is our hope that this "A Wonder Book of Rubber," covering certain phases of the industry, has transfused into you some of the enthusiasm of the industry, some of the dreams of the men who have bound up their lives in the work—men following in the footsteps of Nadier, Hancock, Goodyear, Wickham, and Goodrich—constructive dreamers.